1.0 CONCLUSIONS AND RECOMMENDATIONS

Gallium arsenide (GaAs)-based semiconductor devices are used for a multitude of military and commercial applications in the United States and throughout the world, including lasers, light-emitting diodes, and communications. Manufacturing processes devoted to the fabrication of these devices generate large volumes of wastes which contain the toxic metal arsenic, as well as the economically valuable metal gallium. Arsenic is currently regulated under a number of federal and state laws, including legislation that makes generating companies liable for environmental cleanup at waste disposal sites, even if these wastes have been manifested and disposed of in an approved manner. In addition, even though many of the wastes currently being disposed by the industry are unlisted (e.g. solid GaAs), the toxic arsenic contained therein is regulated, should it be released to the environment (e.g., through the action of acids, present in many landfills). Current gallium prices make recovery of wastes containing this metal economically viable if the recovery process is sufficiently low cost. Therefore, recovery of these metals (As and Ga) from GaAs processing wastes is economically advantageous.

One process has been developed for the on-site recovery of both arsenic and gallium from gallium arsenide (GaAs) solid wastes. The process described herein first involves the thermal separation of GaAs solid wastes into their constituent elements (with a minimum of energy input or additional handling). Each of the separated elements is then purified to the required levels for further crystal growth using low-cost procedures. Because of this three-step approach, the developed procedure can accommodate a wide range of input material characteristics. Prior work with GaAs thermal separation and constituent element purification provided a template for the development of this process, and subsequent thermodynamic consideration of each of these unit operations provided a theoretical basis for process optimization.

A second process was developed for the recovery of both arsenic and gallium from gallium arsenide polishing wastes. The economics associated with the current disposal techniques utilizing ferric hydroxide precipitation dictate that sequential recovery of toxic arsenic and valuable gallium, with subsequent purification and in-house reuse of both, is to the benefit of the gallium arsenide crystal grower. The developed process involves first the removal of the majority of the arsenic and suspended polish as a mixed precipitate of calcium arsenate and polish. This first process step is performed at ambient temperatures and at a pH > 11 using NaOH. At these pH regimes, gallium is retained in solution as a sodium gallate species. Precipitation of virtually pure gallium hydroxide is then accomplished in the next process step through pH adjustment to between 6 and 8 with waste acids. The commonly used ferric hydroxide coprecipitation step is retained as a final treatment step, but because of the removal of the majority of the arsenic, gallium, and polish in the two prior steps, far less waste is land disposed. A patent application has been filed with the United States Patent Office.

In summary, the authors recommend that the processes developed under this cooperative agreement be considered for implementation as in-plant pollution prevention techniques. It is believed to be to the ultimate economic advantage of existing GaAs fabrication companies to minimize or altogether eliminate the amount of toxic arsenic which is disposed of from their manufacturing operations. This not only eliminates "short-term" costs such as manifesting and disposal, but also the much more costly "long-term" liability costs associated with environmental cleanup. Payback for gallium recovery is "immediate", in terms of reduction of operating costs. The payback associated with arsenic recovery is an avoidance of future costs that might be incurred for environmental cleanup. The processes developed will allow recovery and reuse of these materials in a cost-effective and environmentally responsible manner.